AD-A186 266 SAGUARO: A DISTRIBUTED OPERATING SYSTEM BASED ON POOLS OF SERVERS(U) ARIZONA UNIV TUCSON DEPT OF COMPUTER SCIENCE G R ANDREWS 05 FEB 86 AFOSR-TR-87-1224 1/1

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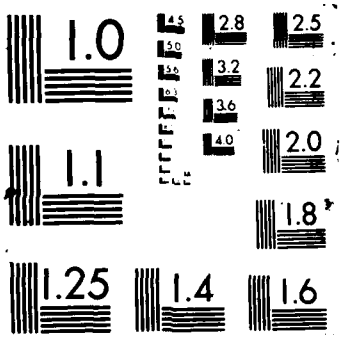
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SECURITY CLASSIFICATION OF THIS P/

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2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR-TR- 87-1224
6a. NAME OF PERFORMING ORGANIZATION University of Arizona	6b. OFFICE SYMBOL (If applicable)
6c. ADDRESS (City, State, and ZIP Code) Dept. of Computer Science Tucson, Arizona 85721	7a. NAME OF MONITORING ORGANIZATION AFOSR/NM
	7b. ADDRESS (City, State, and ZIP Code) AFOSR/NM Bldg 410 Bolling AFB DC 20332-6448
8a. NAME OF FUNDING/SPONSORING ORGANIZATION AFOSR	8b. OFFICE SYMBOL (If applicable) NM
	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER AFOSR-85-0089
8c. ADDRESS (City, State, and ZIP Code) Bldg 410 Bolling AFB DC 20332-6448	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
61102F	2304	A2	

11. TITLE (Include Security Classification)

SAGUARO: A DISTRIBUTED OPERATING SYSTEM BASED ON POOLS OF SERVERS

12. PERSONAL AUTHOR(S)
Professor Gregory R. Andrews

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 1/1/85 TO 12/31/85	2/5/86	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

RESEARCH SUMMARIES:

There are four projects underway that either have used the equipment purchased using the funds from this grant or will use the equipment in the near future. Titles and abstracts of representative papers describing these projects follow. It is the first project-the Saguaro Distributed Operating System-that formed the basis for the URIP grant proposal.

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Block 6b. Office Symbol: Enter the office symbol of the Performing Oganization.

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If the report is in a foreign language and the title is given in both English and a foreign language, list the foreign language title first, followed by the English title enclosed in parentheses. If part of the text is in English, list the English title first followed by the foreign language title enclosed in parentheses. If the title is given in more than one foreign language, use a title that reflects the language of the text. If both the text and titles are in a foreign language, the title should be translated, if possible, unless the title is also the name of a foreign periodical. Transliterations of often used foreign alphabets (see Appendix A of MIL-STD-847B) are available from DTIC in document AD-A080 800.

Block 12. Personal Author(s): Give the complete name(s) of the author(s) in this order: last name, first name, and middle name. In addition, list the affiliation of the authors if it differs from that of the performing organization.

List all authors. If the document is a compilation of papers, it may be more useful to list the authors with the titles of their papers as a contents note in the abstract in Block 19. If appropriate, the names of editors and compilers may be entered in this block.

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Block 13b. Time Covered: Enter the inclusive dates (*year, month, day*) of the period covered, such as the life of a contract in a final contractor report.

Block 14. Date of Report: Enter the year, month, and day, or the year and the month the report was issued as shown on the cover.

Block 15. Page Count: Enter the total number of pages in the report that contain information, including cover, preface, table of contents, distribution lists, partial pages, etc. A chart in the body of the report is counted even if it is unnumbered.

Block 16. Supplementary Notation: Enter useful information about the report in hand, such as: "Prepared in cooperation with...," "Translation of (or by)...," "Symposium...," If there are report numbers for the report which are not noted elsewhere on the form (such as internal series numbers or participating organization report numbers) enter in this block.

Block 17. COSATI Codes: This block provides the subject coverage of the report for announcement and distribution purposes. The categories are to be taken from the "COSATI Subject Category List" (DoD Modified), Oct 65, AD-624 000. A copy is available on request to any organization generating reports for DoD. At least one entry is required as follows:

Field - to indicate subject coverage of report.

Group - to indicate greater subject specificity of information in the report.

Sub-Group - if specificity greater than that shown by Group is required, use further designation as the numbers after the period (.) in the Group breakdown. Use only the designation provided by AD-624 000.

Example: The subject "Solid Rocket Motors" is Field 21, Group 08, Subgroup 2 (page 32, AD-624 000).

Block 18. Subject Terms: These may be descriptors, keywords, posting terms, identifiers, open-ended terms, subject headings, acronyms, code words, or any words or phrases that identify the principal subjects covered in the report, and that conform to standard terminology and are exact enough to be used as subject index entries. Certain acronyms or "buzz words" may be used if they are recognized by specialists in the field and have a potential for becoming accepted terms. "Laser" and "Reverse Osmosis" were once such terms.

If possible, this set of terms should be selected so that the terms individually and as a group will remain UNCLASSIFIED without losing meaning. However, priority must be given to specifying proper subject terms rather than making the set of terms appear "UNCLASSIFIED." Each term on classified reports must be immediately followed by its security classification, enclosed in parentheses.

For reference on standard terminology the "DTIC Retrieval and Indexing Terminology" DRIT-1979, AD-A068 500, and the DoD "Thesaurus of Engineering and Scientific Terms (TEST) 1968, AD-672 000, may be useful.

Block 19. Abstract: The abstract should be a pithy, brief (preferably not to exceed 300 words), factual summary of the most significant information contained in the report. However, since the abstract may be machine-searched, all specific and meaningful words and phrases which express the subject content of the report should be included, even if the word limit is exceeded.

If possible, the abstract of a classified report should be unclassified and consist of publicly releasable information (Unlimited), but in no instance should the report content description be sacrificed for the security classification.

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For further information on preparing abstracts, employing scientific symbols, verbalizing, etc., see paragraphs 2.1(n) and 2.3(b) in MIL-STD-847B.

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Final Report — DoD URIP Grant

Saguaro: A Distributed Operating System Based on Pools of Servers

Grant Number:	AFOSR-85-0089
Grant Duration:	January 1, 1985 - December 31, 1985
Awarded to:	The University of Arizona Tucson, Arizona 85721
Principal Investigator:	Gregory R. Andrews Department of Computer Science
AFOSR Program Manager:	Dr. Robert N. Buchal Directorate on Mathematical and Information Sciences

Gregory R. Andrews
February 5, 1986

1. Equipment Acquired

The equipment purchased using the funds provided by this grant consisted of eight scientific workstations manufactured by Sun Microsystems, Inc. As explained in the interim report, the equipment actually purchased differed slightly from that contained in the original proposal. In particular, we were able to purchase a richer configuration of workstations by taking advantage of new models that were introduced by Sun following the submission of the original proposal. The specifics as to the configuration of machines purchased and their cost are given in Section 3.

2. Research Summaries

There are four projects underway that either have used the equipment purchased using the funds from this grant or will use the equipment in the near future. Titles and abstracts of representative papers describing these projects follow. It is the first project—the Saguaro Distributed Operating System—that formed the basis for the URIP grant proposal.

Project: The Saguaro Distributed Operating System
Paper title: The Design of the Saguaro Distributed Operating System
Authors: G.R. Andrews, R.D. Schlichting, R. Hayes, T. Purdin

This paper describes the design of the Saguaro operating system for computers connected by a local-area network. Systems constructed on such an architecture have the potential advantages of concurrency and robustness. In Saguaro, these advantages are realized at the system level by the use of pools of server processes and decentralized allocation protocols. These advantages are also made available to the user through low-cost mechanisms to control placement of executing commands and files, and to support semi-transparent file replication and access. Saguaro also makes extensive use of a type system to describe user data such as files and to specify the types of arguments to commands and procedures. This enables the system to assist in type checking and leads to a user interface in which command-specific templates are available to facilitate command invocation. A mechanism is also provided to enable users to construct applications containing general graphs of communicating commands.

Project: The Saguaro Distributed Operating System
Paper title: Mechanisms to Enhance File Availability in Distributed Systems
Authors: R.D. Schlichting, G.R. Andrews, T. Purdin

The design of the file system component of the Saguaro distributed operating system is described. The goal of this file system is to enhance file availability in a way that is easy to use yet inexpensive to implement. The logical file system seen by users forms a single tree and file names are location-transparent. However, any file can be placed at the user's discretion in any of the physical file systems. Also, two mechanisms—reproductions and metafiles—are provided to support file replication. Together these mechanisms enable a user to set up collections of replicated files and then access them as if they were normal, unreplicated files. Moreover, a file open is guaranteed to succeed if at least one of the copies is available. A prototype implementation of reproductions and metafiles on top of Berkeley Unix has confirmed that these mechanisms are also useful in

existing systems, and that they are relatively inexpensive to implement.

Project: The SR Distributed Programming Language
Paper title: An Overview of the SR Language and Implementation
Authors: G.R. Andrews, R.A. Olsson, M. Coffin, I.J.P. Elshoff, K. Nilsen, T. Purdin

SR is a language for programming distributed systems ranging from operating systems to application programs. Based on our experience, the language has evolved considerably during the past year. This paper describes the current version of the language and gives an overview of its implementation. The main language constructs are still resources and operations. Resources encapsulate processes and variables they share; operations provide the primary mechanism for process interaction. One way in which SR has changed is that both resources and processes are now created dynamically. Another change is that the mechanisms for operation invocation—**call** and **send**—and operation implementation—**proc** and **in**—have been extended and integrated. Consequently, all of local and remote procedure call, rendezvous, asynchronous message passing, multicast, and semaphores are supported. We have found this flexibility to be very useful for distributed programming. Moreover, by basing SR on a small number of well-integrated concepts, the language is also relatively simple and has a reasonably efficient implementation.

Project: Distributed and Mixed Language Programming
Paper title: Facilitating Mixed Language Programming in Distributed Systems
Authors: R. Hayes, R.D. Schlichting

An approach for facilitating mixed language programming in distributed systems is presented. It is based on adding a generic remote procedure call facility to each language, and the use of a type system to describe procedural interfaces, as well as data to be transferred between procedures. This type scheme also specifies a machine independent representation for all data. By defining standard mappings for each programming language, the data conversions required for cross-language calls may be performed, automatically in most cases, by active agents that provide the interface between program components written in different languages. When necessary, explicit control of the conversion is possible. A prototype of this system has been constructed using Berkeley Unix.

Project: Designing Fault-Tolerant Software
Paper title: Failure Handling in Distributed Programming Languages
Authors: R.D. Schlichting, T. Purdin

One property that makes failures difficult to handle in programs is that the actions of a failed component may occur asynchronously with respect to execution of the program. In this paper, an approach to dealing with this asynchrony is presented. It is based on treating a failure as an event in a concurrent system of processes, and then integrating failure handling mechanisms into distributed programming languages. The technique is illustrated by considering the class of failures suffered by fail-stop processors, and proposing extensions to the Syn-

chronizing Resources (SR) distributed programming language to handle such failures. Two SR programs using these mechanisms are presented.

3. Equipment Configuration and Cost

The following abbreviations are used in the equipment descriptions.

C = CPU
E = Ethernet controller
M = monitor
K = keyboard
m = mouse
V = video controller

model	descrip.	price
Deskside SunStation (diskfull):		
Sun-2/120	C,E,1MB,M,K,m,V	14365.00
Opt10	1MB mem	2805.00
Opt63	130MB disk	11815.00
Opt73	1/4" tape drive	3400.00
Rackmountable SunStation:		
Sun/Rack01	76" rack	3315.00
Sun-2/170R1	C,E,2MB	16065.00
Opt02	software	382.50
Opt40	2nd E	1700.00
Opt68R1	380MB disk	16915.00
ETHKET	transceiver,cable	500.00
Desktop SunStation (diskfull):		
Sun-2/50-2	C,E,2MB,M,K,m,V	7565.00
Opt01	software	382.50
Opt55	71MB disk	5015.00
ETHKET	transceiver,cable	500.00
Desktop SunStation (diskfull):		
Sun-2/50-2	C,E,2MB,M,K,m,V	7565.00
Opt01	software	382.50
Opt55	71MB disk	5015.00
ETHKET	transceiver,cable	500.00
Desktop SunStation (diskfull):		
Sun-2/50-4	C,E,4MB,M,K,m,V	10115.00
Opt01	software	382.50
Opt55	71MB disk	5015.00
ETHKET	transceiver,cable	500.00

Desktop SunStations (diskless):

Sun-2/50-2	C,E,2MB,M,K,m,V	7565.00
ETHKET	transceiver,cable	500.00
Sun-2/50-2	C,E,2MB,M,K,m,V	7565.00
ETHKET	transceiver,cable	500.00
Sun-2/50-2	C,E,2MB,M,K,m,V	7565.00
ETHKET	transceiver,cable	500.00

Total Acquisition Cost: 138,395.00

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